AccuRange™ High Speed Interface
PCI Formats

User's Manual

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For use with AccuRange HSIF- PCI
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Acuity
A product line of Schmitt Measurement Systems, Inc.
2765 NW Nicolai St.
Portland, OR 97210
www.acuityresearch.com

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1. AccuRange PCI High Speed Interface (HSIF) Card

1.1 General Description

The AccuRange PCI High Speed Interface (PCI HSIF) is an interface computer board that takes samples from the AR4000 optical rangefinder. Samples come over the bus in a 16 byte format that includes a 32 bit range value, two 32 bit encoder values, and 1 byte values for signal strength, ambient light, and sensor internal temperature and general purpose input bits. These inputs, along with external enable/disable control of sampling, allow precise synchronization with external events.

The interface board operates by measuring the range-dependent pulse width output of the AR4000. To use the 4000 sensor with this High Speed Interface, the *Current Loop* option must not be installed in the sensor. Each pulse on the pulse width output is timed on the interface board by a timer with a clock rate of 8 GHz. The sample rate of the interface is therefore controlled by the sample rate configuration for AR4000 device. Since the pulse width output can be set to repeat at up to 50 KHz, that is the maximum sample rate of the interface.

The data collected by the PCI High Speed Interface is not scaled or calibrated in any way. It can be used to create calibrated distance output using software modules and tables supplied with the interface or though user-written algorithms. The data can be used to calculate distance as each sample is collected, although the more typical application will collect a batch of samples and create distance readings from the entire group after high-speed collection is finished. Data may be collected in a buffered streaming mode or a low-level direct access mode.

Other features of the interface include memory buffer indicators for the number of samples available, external sample start/stop control, and three general purpose input bits that allow synchronous recording of events while sampling.

The board comes standard with power control circuitry for two small motors. This is not full servo control, but it allows motor power to be programmed. If the motors have encoders, the encoders may be sampled with the sensor data to provide position information in the sample stream in scanning systems. Each motor can be driven with up to 2 amps at 12 to 15 volts. Power for the DC-level controlled motors must be supplied to the board.

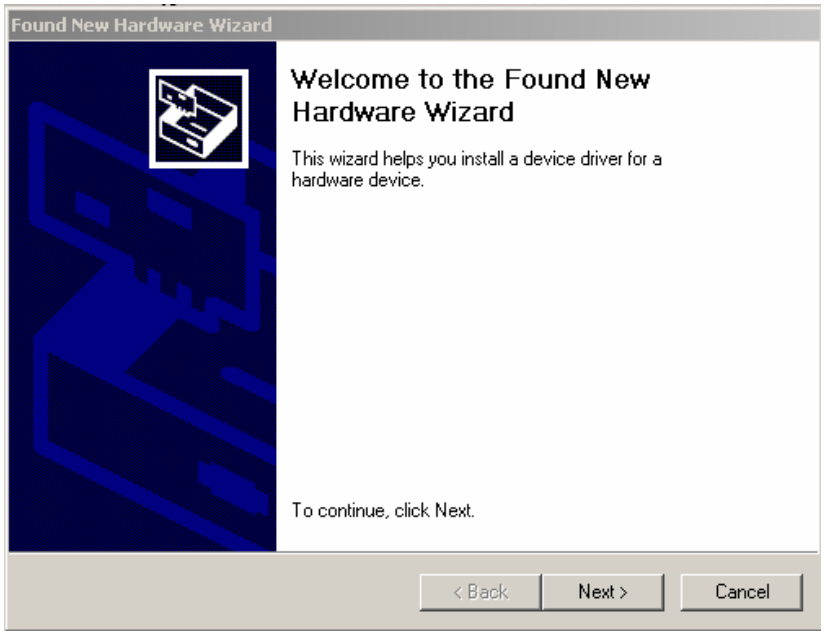
The AR4000 PCI High Speed Interface can be ordered with either single-ended or differential encoders. If you are using your own motor and encoder with a line scanner application, you must specify which encoder type you will be using with your PCI HSIF.

1.2 HSIF Card Installation

The PCI HSIF card is compatible with Windows® 98, 2000 and XP. While the PC is turned "off", install the card into an available PCI bus slot.

1.2.1 Windows 2000 driver installation

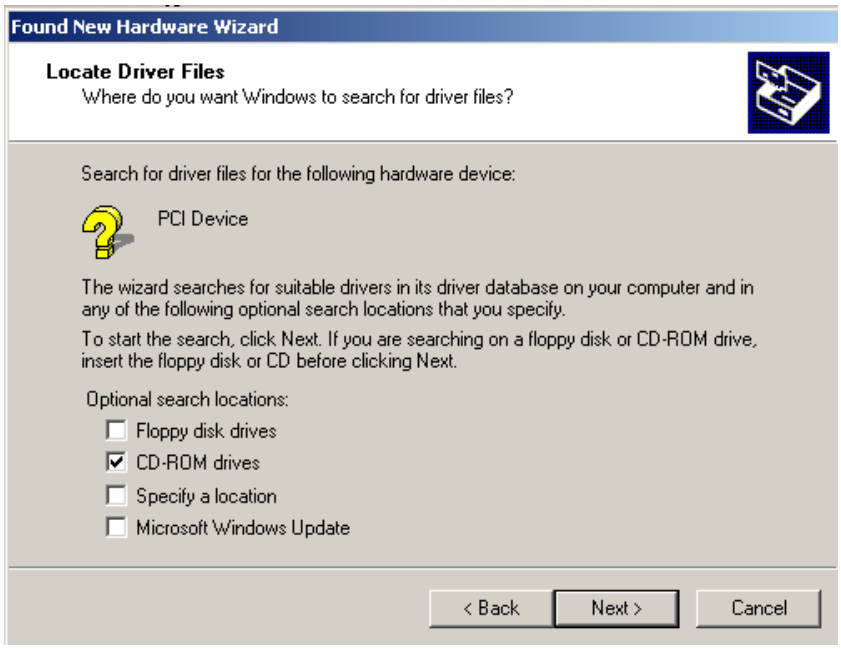
When you turn on the PC, the following dialog box appears.


Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
This wizard helps you install a device driver for a hardware device.
To continue, click Next.
< Back
Next >
Cancel

Click Next. Then, the next dialog box appears.

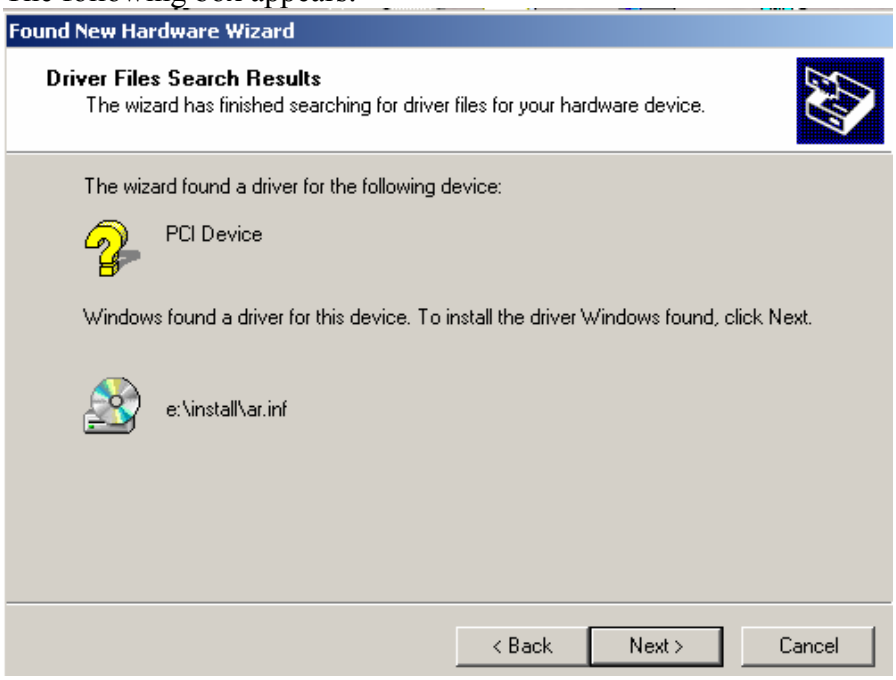
Found New Hardware Wizard
Install Hardware Device Drivers
A device driver is a software program that enables a hardware device to work with an operating system.
This wizard will complete the installation for this device:
PCI Device
A device driver is a software program that makes a hardware device work. Windows needs driver files for your new device. To locate driver files and complete the installation click Next.
What do you want the wizard to do?
Search for a suitable driver for my device (recommended)
Display a list of the known drivers for this device so that I can choose a specific driver
< Back
Next >
Cancel

Choose “Search for a suitable driver for my device” and hit NEXT. The following box appears:

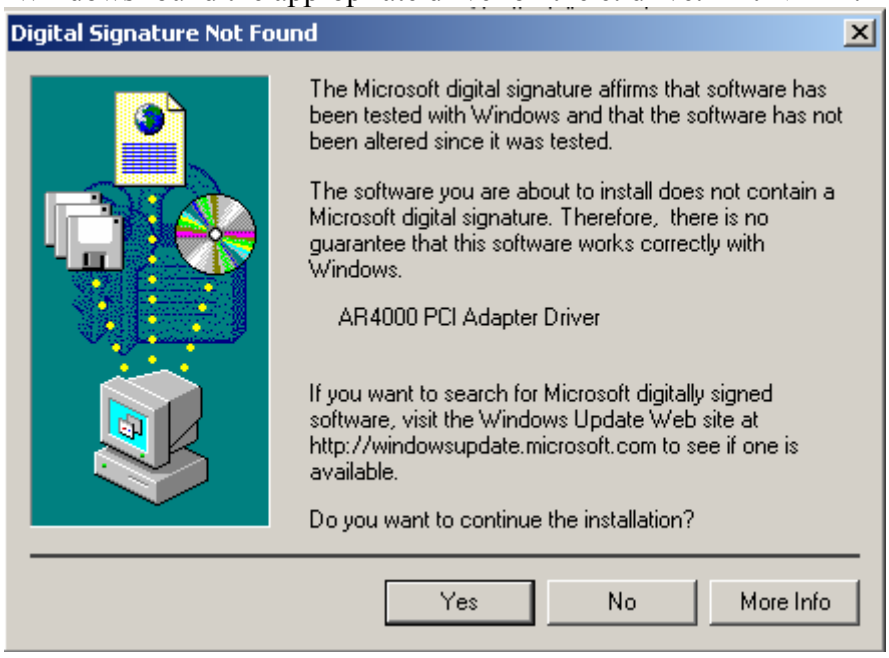

Found New Hardware Wizard
Locate Driver Files
Where do you want Windows to search for driver files?
Search for driver files for the following hardware device:
PCI Device
The wizard searches for suitable drivers in its driver database on your computer and in any of the following optional search locations that you specify.
To start the search, click Next. If you are searching on a floppy disk or CD-ROM drive, insert the floppy disk or CD before clicking Next.
Optional search locations:
Floppy disk drives
CD-ROM drives
Specify a location
Microsoft Windows Update
< Back
Next >
Cancel

Choose “CD-ROM drives” and make sure that the AccuRange PCI High Speed Interface installation CD-ROM is loaded into the CD-ROM drive prior to hitting NEXT.

The following box appears:


Found New Hardware Wizard
Driver Files Search Results
The wizard has finished searching for driver files for your hardware device.
The wizard found a driver for the following device:
PCI Device
Windows found a driver for this device. To install the driver Windows found, click Next.
e:\install\ar.inf
< Back
Next >
Cancel

Windows found the appropriate driver on the e: drive. Hit NEXT.


Digital Signature Not Found
The Microsoft digital signature affirms that software has been tested with Windows and that the software has not been altered since it was tested.
The software you are about to install does not contain a Microsoft digital signature. Therefore, there is no guarantee that this software works correctly with Windows.
AR4000 PCI Adapter Driver
If you want to search for Microsoft digitally signed software, visit the Windows Update Web site at http://windowsupdate.microsoft.com to see if one is available.
Do you want to continue the installation?
Yes
No
More Info

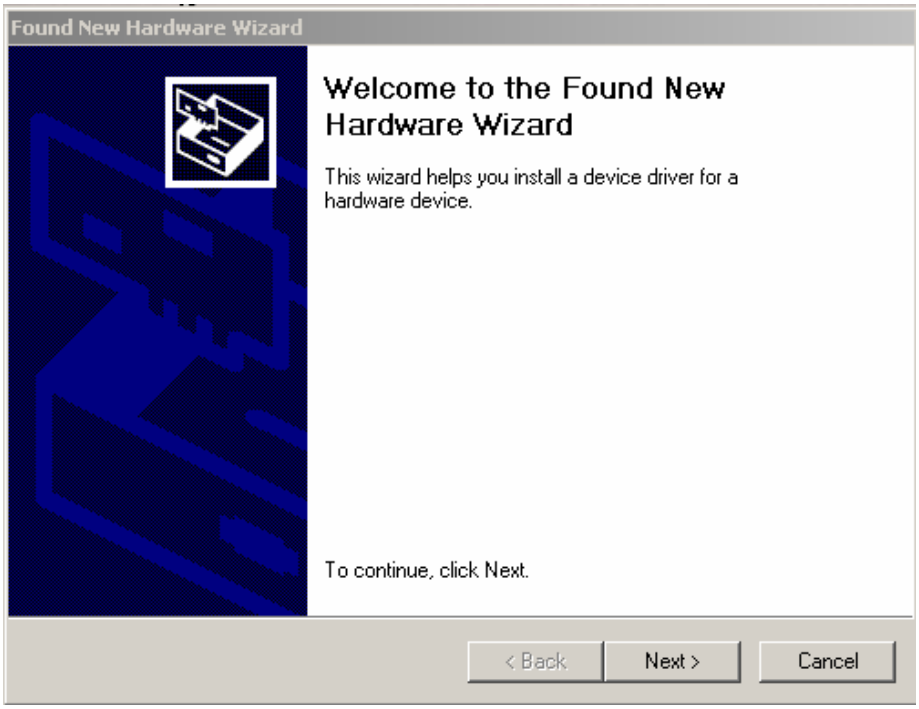
The driver should be successfully installed. Hit YES.

Found New Hardware Wizard
Completing the Found New Hardware Wizard
AR4000 PCI Adapter Driver
Windows has finished installing the software for this device.
To close this wizard, click Finish.
< Back
Finish
Cancel

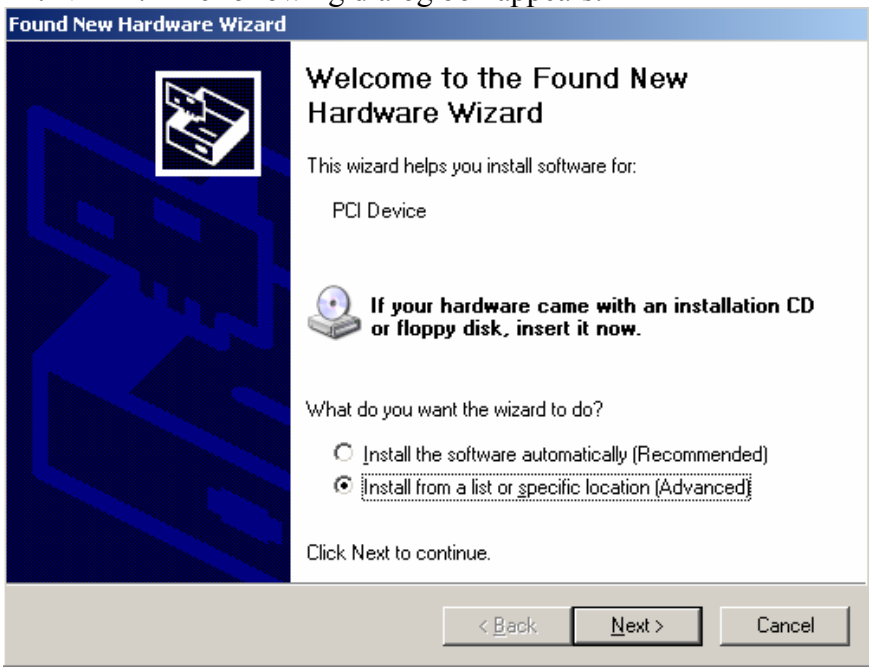
Installation is complete. Hit FINISH.

1.2.2 Windows XP driver installation

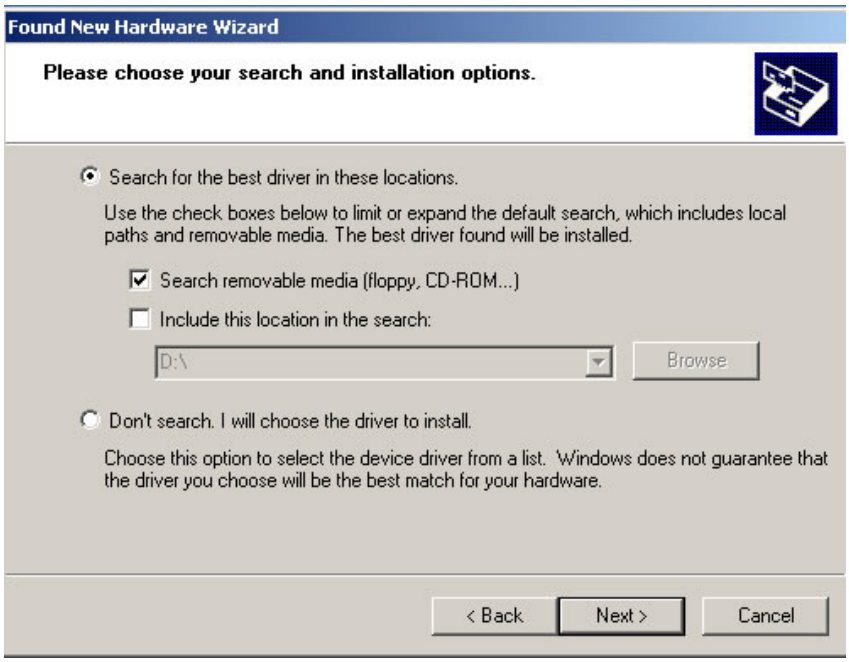
Be sure the installation CD-ROM is in the drive and turn on the power to the PC


Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
This wizard helps you install a device driver for a hardware device.
To continue, click Next.
< Back
Next >
Cancel

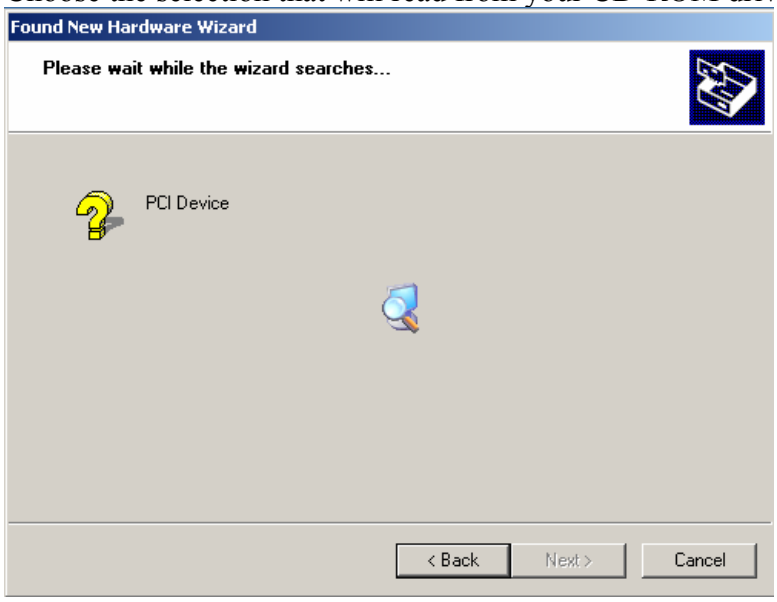
Hit NEXT. The following dialog box appears:


Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
This wizard helps you install software for:
PCI Device
If your hardware came with an installation CD or floppy disk, insert it now.
What do you want the wizard to do?
Install the software automatically (Recommended)
Install from a list or specific location (Advanced)
Click Next to continue.
< Back
Next >
Cancel

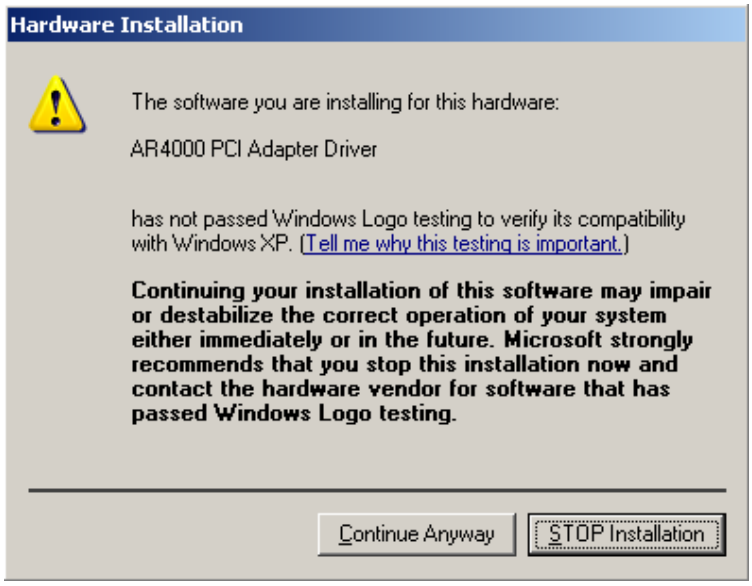
Choose "Install from a list or specific location (Advanced)" and hit NEXT. The following box appears:


Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
D:\
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

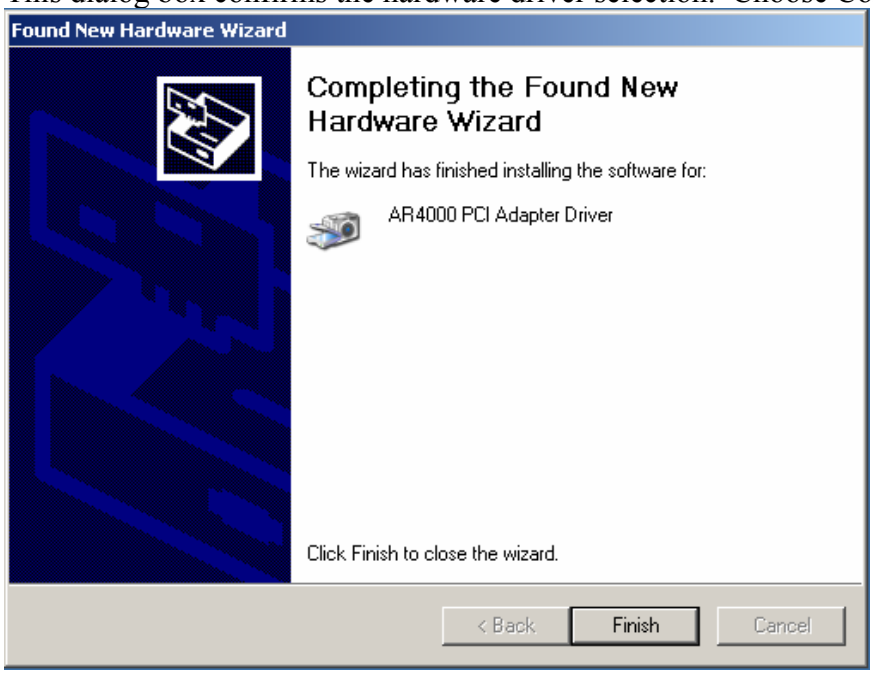
Choose the selection that will read from your CD-ROM drive and hit NEXT.



This dialog box appears while the system searches for the PCI driver.


Hardware Installation
The software you are installing for this hardware:
AR4000 PCI Adapter Driver
has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)
Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the hardware vendor for software that has passed Windows Logo testing.
Continue Anyway
STOP Installation

This dialog box confirms the hardware driver selection. Choose Continue Anyway.


Found New Hardware Wizard
Completing the Found New Hardware Wizard
The wizard has finished installing the software for:
AR4000 PCI Adapter Driver
Click Finish to close the wizard.
< Back
Finish
Cancel

When the hardware is installed, choose FINISH.

1.3 Included Software

1.3.1 CD Directory Tree

The HSIF product includes a CD with the following contents:

\install	- driver installation files
\dll	- dynamic link library installation files
\docs	- API and Users Guide
\examples\bin	- precompiled programs, built under Windows XP
\examples\hsiftest	- example *hsiftest* project and source code
\examples\dist_cap	- example *dist_cap* project and source code
\examples\distance	- example *distance* project and source code
\examples\hs_enc	- example *hs_enc* project and source code (with encoder)
\examples\utilities	- serial interface and dynamic link library utilities
\calibration	- calibration files for sensor and PCI card

1.3.2 Demonstration Programs

Two demonstration programs with C source code which run under Windows 2000/XP are supplied with the AccuRange High Speed Interface: *hsiftest*, *distance*, *dist_cap*, and *hs_enc.* The programs were compiled with Microsoft Visual C++ 6.0 under Windows XP.

1.6.3.1 Demonstration Program One: *hsiftest*

hsiftest is a command-line program built from the project "hsiftest" located in directory \examples\ hsiftest on the CD.

hsiftest exercises all off the features of the High Speed Interface. It takes 2 command line arguments, the serial communications port number to which the AccuRange is attached, the card number of the installed High Speed Interface card and the calibration file. See the source code for more info.

As an example, the following command-line entry would be used to start *hsiftest* for an AccuRange attached to comport 1 using the first installed PCI HSIF card and lookuphs calibration file.

```
hsiftest 1 1 lookuphs
```

Once *hsiftest* is started, follow the instructions on the screen

1.6.3.2 Demonstration Program Two: *Distance*

distance is a command-line program built from the project "distance" located in directory \examples\distance on the CD included with the PCI HSIF card.

distance samples data from the High Speed Interface and prints distance in inches, as well as averaged data obtained from the interface. It takes 5 command line arguments: The serial COM port number, the installed card number, the sample period in microseconds, the name of the file containing the calibration data, the number of samples to calibrate and average between printouts to the screen, and the total number of range captures to print before exiting.

The following command-line demonstrates the program *distance* for an AccuRange connected to comport 1 and interface card 1, a sample rate of 10,000 samples/sec (100µs/sample), the calibration file `lookuphs`, 10,000 averages per output line, and prints 500 lines of range capture data before exiting.

```
distance 1 1 100 lookuphs 10000 500
```

1.6.3.3 Demonstration Program Three: *dist_cap*

dist_cap is a command-line program built from the project "dist_cap" located in directory \examples\dist_cap on the CD.

dist_cap captures unprocessed raw data from the AccuRange sensor and records it to disk. Afterwards, it processes the raw data and creates several output files which can be loaded into programs such as Matlab or Excel for analysis. It takes 6 command line arguments: The serial COM port number, the installed card number, the sample period in microseconds, the name of the file containing the calibration data, the number of samples to read per call to the driver, number of calls to the driver, the max range of the sensor (650 inches for full range), and the capture file base name.

As an example, the following command-line entry would be used to start *dist_cap* for an AccuRange attached to comport 1 using the first installed PCI HSIF card and lookuphs calibration file. This example captures 70,000 continuous samples t a 5us sampling period (200kHz sampling rate) from the Accurange via 10 calls for 7,000 samples to the driver. The max range is set to 650 inches.

```
dist_cap 1 1 5 lookuphs 7000 10 650 my_cap
```

dist_cap will generate a readable file with processed distances called *my_cap.txt.*

1.6.3.4 Demonstration Program Four: *hs_enc*

hs_enc is a command-line program built from the project "hs_enc" located in directory \examples\hs_enc on the CD.

hs_enc samples data from the High Speed Interface and prints distance in inches, as well as averaged data obtained from the interface and angular data measured from the scanning encoder.

It takes 5 command line arguments: The serial COM port number, the installed card number, the sample period in microseconds, the name of the file containing the calibration data, the number of samples to calibrate and average between printouts to the screen, and the total number of range captures to print before exiting.

The following command-line demonstrates the program *hs_enc* for an AccuRange connected to comport 1 and interface card 1, a sample rate of 10,000 samples/sec (100µs/sample), the calibration file `lookuphs`, 10,000 averages per output line, prints 500 lines of range capture data before exiting, sets the motor power to half voltage (128), sets the number of pulses per encoder revolution at 8192, and sets the maximum range to 650 inches.

```
hs_enc 1 1 100 lookuphs 10000 500 128 8192 650
```

1.4 Sensor Configuration and Sample Rate

When using the High Speed Interface, all configurations of the 4000 are done via the serial port or push-button interface, just as it would be when using the sensor without the High Speed Interface. The communication path from the AR4000 to the High Speed Interface is a one-way data path only; the sensor cannot be configured through the Interface. Since the sample rate of the Interface is controlled by the rate of the pulse width output of the AR 4000, using the Set Sample Interval command over the serial port will set the sample rate for the Interface, with one limitation. The lowest rate at which the internal sampling and therefore the pulse width output of the sensor can operate is 31 samples per second (32 milliseconds per sample). Setting lower sample rates will not reduce the pulse width output frequency or the sample rate of the Interface.

To obtain the slowest possible sample rate from the High Speed Interface and the maximum resolution per sample, use the serial interface to configure the 4000 for a maximum expected range of 9950 inches, and then set the sample rate. Setting the maximum range to shorter distances (including the default setting) may cause the pulse width to repeat at higher frequencies than the sample rate set, depending on the maximum expected range and sample rate specified. For short maximum range settings, the pulse frequency will be about 5 KHz for sample rates below that.

The maximum sample rate is 50,000 samples per second (20 microseconds/sample).

1.5 Motor Power

The AR4000 PCI High Speed Interface has two motor power control and encoder reading channels. Each motor may be set to one of 256 software controlled power levels via commands to the board. If the motors have encoders which are connected to the encoder inputs, two 8-bit values from the encoders are decoded and inserted into the data stream, giving the position of each motor. If the encoders provide index pulses, these can be applied to two of the general purpose input lines and used to determine the absolute positions of the motors. See the description of the 25 pin I/O connector for encoder connection details.

If motors are to be driven by the power amplifier on the board, the motors and motor power must be connected to P2. Motor 1 should be connected between pins 14 and 16, and motor 2 between pins 1 and 2. A separate power supply is required to drive the motors. Connect the motor power supply to pin 3 and the power supply ground to pin 15.

1.6 I/O Connectors

There are two connectors on the High Speed Interface. The 9 pin connector (P1) supplies power and receives signals from the AR4000 sensor. The 25 pin connector (P2) is used for powering the motors and reading the motor encoders, general purpose inputs, and sample control input.

1.6.1 9 Pin Power and Signal Connector P1

Pin	4000 Wire	Function	Direction
1	Red	Power, +5V (5-6V)	Out
2	Black	Ground	
3	Orange	Heater Power, +5V (4.5-7V)	Out
4	Brown	Heater Power Return	
5	Yellow	Temperature, 0-5 V	In
6	Blue	Pulse Width Range Signal	In
7	Green	Ambient light signal, 0-5 V	In
8	Purple	Amplitude signal, 0-5 V	In
9	Not Used	Laser Control, 0-5V	Out

P1: Power and Signal Connector Wiring

1.6.2 Power and Signal Connector Description

The line descriptions for P1 are the same as the descriptions of the power and signal lines in the AR4000 Power and Signal Cable Wire Description section. Pins 1-4 supply sensor power and sensor heater power and ground lines. The remaining lines are inputs for the signals from the AR4000 sensor. Pins 5, 7, and 8 are the inputs for the analog signals, with 2K impedance. Pin 6 is the input for the pulse width range signal.

1.6.3 25 Pin I/O Connector P2

P2 includes general purpose input lines, a sample start/stop control line, quadrature encoder input lines, and power for encoders or other applications. There are two configurations, one for a

single-ended encoder and one for an index pulse, and one for a *differential encoder* and index pulse.

1.6.3.1 P2 Pin Descriptions: Single-Ended Encoder

Below is a table of pin descriptions for a PCI HSIF card with Single-Ended Encoders. See section 1.4.3.2 for Differential Encoders.

	Top Row			***Bottom Row***	
Pin	**Function**	**Direction**	**Pin**	**Function**	**Direction**
1	Motor 2 Control	Out	14	Motor 1 Control	Out
2	Motor 2 Return	Out	15	Motor Power Ground	
3	Motor Power Supply	In	16	Motor 1 Return	Out
4	Ground		17	Laser Control	Out
5	+5V Power, 100 mA.	Out	18	+5V Power, 100 mA	Out
6	Ground		19	Motor 2 Encoder Ch A	In
7	Ground		20	Motor 2 Encoder Ch B	In
8	Ground		21	Motor 1 Encoder Ch A	In
9	Ground		22	Motor 1 Encoder Ch B	In
10	Ground		23	Ground	
11	Ground		24	General Purpose Input 1/ Encoder 1 Index Pulse	In
12	Start/Stop Sample Ctrl	In	25	General Purpose Input 3	In
13	General Purpose Input 2/ Encoder 2 Index Pulse	In			

P2: I/O Connector

Pin 1: Motor 2 Control

If used, motor 2 should be connected between this pin and pin 2. The output voltage level is varied as commanded to control the variable voltage motor.

Pin 2: Motor 2 Return.

If used, motor 2 should be connected between this pin and pin 1.

Pin 3: Motor Power.

The external power supply for the motors should be applied to this line, at +12 to +15 Volts, depending on the motor used. The line may draw up to 2 amps.

Pin 4: Ground

May be used as ground for encoders or other hardware powered by +5V on pins 5 and 18

Pin 5: +5V power output.

Primarily intended as power for the motor 1 encoder, but it may be used to drive other hardware, up to 100 mA maximum

Pins 6-10: Ground

May be used as ground for encoders or other hardware powered by +5V on pins 5 and 18

Pin 11: Ground.

May be used as ground for encoders or other hardware powered by +5V on pins 5 and 18

Pin 12: Start/Stop Sample Control Input.

When high, this input enables sampling and samples will be taken until the on-board buffer is full. When pulled low, sampling will stop. Samples are always completed, so that a full 8 byte sample is always buffered. This line is pulled up with an on-board 10Kohm resistor, so sampling is enabled when the input is left open. The first sample following resumption of sampling after stopping the sampling will not contain valid data, and must be read and discarded.

Pin 13: General purpose input bit 2 / Motor 2 index pulse input.

This may be used to sample external signals. The value of the bit is included in the sampled data stream. This pin is intended to sample motor encoder index pulses or other events to synchronize the sample data with the event. The signal is latched high so that any high signal of 100 nanoseconds or longer during a sample interval will appear as a high level following sample. This is intended for use with encoder index pulses.

Pin 14: Motor 1 Control.

If used, motor 1 should be connected between this pin and pin 14. The output voltage level is varied as commanded to control the variable voltage motor.

Pin 15: Motor Power Ground.

The external power supply ground for the motors should be connected to this pin.

Pin 16: Motor 1 Ground.

If used, motor 2 should be connected between this pin and pin 16.

Pin 17: Laser Control.

A 0-5V signal used to turn the laser on or off.

Pin 18: +5V power.

Primarily intended as power for the motor 2 encoder, but it may be used to drive other hardware, up to 100 milliamps maximum

Pin 19: Motor 2 Encoder Channel A.

If the motor control option is installed on the board, this input is decoded with pin 20 as a quadrature encoder signal from motor 2. The input should be a TTL-level signal and may switch at up to 1.5 Mhz. The encoder positions are converted to 8 bit position values that ate included in the data stream. Each transition of pins 19 or 20 causes an up or down count in the position, so each quadrature cycle is effectively multiplied by 4 for the best possible resolution.

Pin 20: Motor 2 Encoder Channel B.

If the motor control option is installed on the board, this input is decoded with pin 19 as a quadrature encoder signal from motor 2. The input should be a TTL-level signal and may switch at up to 1.5 Mhz.

Pin 21: Motor 1 Encoder Channel A.

If the motor control option is installed on the board, this input is decoded with pin 22 as a quadrature encoder signal from motor 1. The input should be a TTL-level signal and may switch at up to 1.5 Mhz. The encoder positions are converted to 8 bit position values that are included in the data stream. Each transition of pins 21 or 22 causes an up or down count in the position, so each quadrature cycle is effectively multiplied by 4 for the best possible resolution.

Pin 22: Motor 1 Encoder Channel B.

If the motor control option is installed on the board, this input is decoded with pin 21 as a quadrature encoder signal from motor 1. The input should be a TTL-level signal and may switch at up to 1.5 Mhz.

Pin 23: Ground

May be used as ground for encoders or other hardware powered by +5V on pins 5 and 18.

Pin 24: General purpose input bit 1 / Motor 1 index pulse input.

This may be used to sample external signals. The value of the bit is included in the sampled data stream. This pin is intended to sample motor encoder index pulses or other events to synchronize the sample data with the event. The signal is latched high so that any high signal of 100 nanoseconds or longer during a sample interval will appear as a high level following sample. This is intended for use with encoder index pulses.

Pin 25: General purpose input bit 3.

This may be used to sample external signals. The value of the bit will be inverted and inserted into the sample data stream. This may be used to sample events in order to synchronize the sample data with the event.

1.6.3.2 P2 Pin Descriptions: Differential Encoders

Below is a table of pin descriptions for a PCI HSIF card with Differential Encoders:

	Top Row			*Bottom Row*	
Pin	**Function**	**Direction**	**Pin**	**Function**	**Direction**
1	Motor 2 Control	Out			
			14	Motor 1 Control	Out
2	Motor 2 Return	Out			
			15	Motor Power Ground	
3	Motor Power Supply	In			
			16	Motor 1 Return	Out
4	Ground				
			17	Laser Control	Out
5	+5V Power, 100 mA.	Out			
			18	+5V Power, 100 mA	Out
6	Motor 2 Encoder Ch A-	In			
			19	Motor 2 Encoder Ch A+	In
7	Motor 2 Encoder Ch B-	In			
			20	Motor 2 Encoder Ch B+	In
8	Motor 1 Encoder Ch A-	In			
			21	Motor 1 Encoder Ch A+	In
9	Motor 1 Encoder Ch B-	In			
			22	Motor 1 Encoder Ch B+	In
10	Ground				
			23	General Purpose Input 1/ Encoder 1 Index Pulse-	In
11	General Purpose Input 2/ Encoder 2 Index Pulse-	In			
			24	General Purpose Input 1/ Encoder 1 Index Pulse+	In
12	Start/Stop Sample Ctrl,	In			
			25	General Purpose Input 3	In
13	General Purpose Input 2/ Encoder 2 Index Pulse+	In			

P2: I/O Connector

Pin 1: Motor 2 Control

If used, motor 2 should be connected between this pin and pin 2. The output voltage level is varied as commanded to control the variable voltage motor.

Pin 2: Motor 2 Return.

If used, motor 2 should be connected between this pin and pin 1.

Pin 3: Motor Power.

The external power supply for the motors should be applied to this line, at +12 to +15 Volts, depending on the motor used. The line may draw up to 2 amps.

Pin 4: Ground

May be used as ground for encoders or other hardware powered by +5V on pins 5 and 18.

Pin 5: +5V power output.

Primarily intended as power for the motor 1 encoder, but it may be used to drive other hardware, up to 100 mA maximum.

Pin 6: Motor 2 Encoder Ch A-

Negative input of motor 2 encoder channel A differential pair. See pin 19 for functional description.

Pin 7: Motor 2 Encoder Ch B-

Negative input of motor 2 encoder channel B differential pair. See pin 20 for functional description.

Pin 8: Motor 1 Encoder Ch A-

Negative input of motor 1 encoder channel A differential pair. See pin 21 for functional description.

Pin 9: Motor 1 Encoder Ch B-

Negative input of motor 1 encoder channel B differential pair. See pin 22 for functional description.

Pin 11: General Purpose Input 2 / Encoder 2 Index Pulse-

Negative input of motor 2 index pulse differential pair or general purpose input 2. See pin 13 for functional description.

Pin 12: Start/Stop Sample Control Input.

When high, this input enables sampling and samples will be taken until the on-board buffer is full. When pulled low, sampling will stop. Samples are always completed, so that a full 8 byte sample is always buffered. This line is pulled up with an on-board 10Kohm resistor, so sampling

is enabled when the input is left open. The first sample following resumption of sampling after stopping the sampling will not contain valid data, and must be read and discarded.

Pin 13: General purpose input bit 2 / Motor 2 index pulse input+.

Positive input of motor 2 index pulse differential pair or general purpose input 2. This may be used to sample external signals. The value of the bit will is included in the sampled data stream. This may be used to sample motor encoder index pulses or other events in order to synchronize the sample data with the event. The signal is latched high so that any high signal of 100 nanoseconds or longer during a sample interval will appear as a high level the following sample. This is intended for use with encoder index pulses.

Pin 14: Motor 1 Control.

If used, motor 1 should be connected between this pin and pin 14. The output voltage level is varied as commanded to control the variable voltage motor.

Pin 15: Motor Power Ground.

The external power supply ground for the motors should be connected to this pin.

Pin 16: Motor 1 Ground.

If used, motor 2 should be connected between this pin and pin 16.

Pin 17: Laser Control.

A 0-5V signal used to turn the laser on or off.

Pin 18: +5V power.

Primarily intended as power for the motor 2 encoder, but it may be used to drive other hardware, up to 100 milliamps maximum.

Pin 19: Motor 2 Encoder Channel A+

Positive input of motor 2 encoder channel A differential pair. If the motor control option is installed on the board, this input is decoded with pin 20 as a quadrature encoder signal from motor 2. The input should be a TTL-level signal and may switch at up to 1.5 Mhz. The encoder positions are converted to 8 bit position values that ate included in the data stream. Each transition of pins 19 or 20 causes an up or down count in the position, so each quadrature cycle is effectively multiplied by 4 for the best possible resolution.

Pin 20: Motor 2 Encoder Channel B+.

Positive input of Motor 2 encoder channel B differential pair. If the motor control option is installed on the board, this input is decoded with pin 19 as a quadrature encoder signal from motor 2. The input should be a TTL-level signal and may switch at up to 1.5 Mhz.

Pin 21: Motor 1 Encoder Channel A+.

Positive input of motor 1 encoder channel A differential pair. If the motor control option is installed on the board, this input is decoded with pin 22 as a quadrature encoder signal from motor 1. The input should be a TTL-level signal and may switch at up to 1.5 Mhz. The encoder positions are converted to 8 bit position values that are included in the data stream. Each transition of pins 21 or 22 causes an up or down count in the position, so each quadrature cycle is effectively multiplied by 4 for the best possible resolution.

Pin 22: Motor 1 Encoder Channel B+.

Positive input of motor 1 encoder channel B differential pair. If the motor control option is installed on the board, this input is decoded with pin 21 as a quadrature encoder signal from motor 1. The input should be a TTL-level signal and may switch at up to 1.5 Mhz.

Pin 23: General Purpose Input 1 / Encoder 1 Index Pulse-

Negative input of motor 1 index pulse differential pair or general purpose input 1. See pin 24 for functional description.

Pin 24: General purpose input bit 1 / Motor 1 index pulse input+.

Positive input of motor 1 index pulse differential pair or general purpose input 1. This may be used to sample external signals. The value of the bit will is included in the sampled data stream. This may be used to sample motor encoder index pulses or other events in order to synchronize the sample data with the event. The signal is latched high so that any high signal of 100 nanoseconds or longer during a sample interval will appear as a high level the following sample. This is intended for use with encoder index pulses.

Pin 25: General purpose input bit 3.

This may be used to sample external signals. The value of the bit will be inverted and inserted into the sample data stream. This may be used to sample events in order to synchronize the sample data with the event.

1.7 HSIF Library Routines

The AR4000 PCI High Speed Interface card application program interface (API) employs routines that are accessed using a static linked library. Descriptions of those basic API's are listed below

1.7.1 Initialize the library

Initialize the library before using any of its functions.

```
BOOL HsifDllInit()
```

Returns:

TRUE	library initialization successful
FALSE	library failed to initialize

1.7.2 Opening communications with the card

Open communication with a PCI HSIF card.

```
HSIF_HANDLE HsifOpen(
   DWORD hsifNum,
   DWORD comHandle)
```

`hsifNum` Open communication with a PCI HSIF card. hsifNum is a number 0 – 4, denoting the card number assignment. If hsifNum is 0, the first available HSIF device is returned as enumerated by Windows.

`comHandle` If a serial port is dedicated to the AR4000 sensor, a handle to the opened COM device can be included here. The AR4000 will enable the PWM output and set the sample period and maximum range to their default values.

Returns:

HSIF_HANDLE	handle (0-4) to hsifCard resource
HSIF_INVALID_HANDLE	invalid or null handle

1.7.3 Closing access to the card

Close the application's access to the PCI HSIF card. Calling the card with an invalid handle is not destructive.

```
HSIF_RESULT HsifClose(
   HSIF_HANDLE hsifCard)
```

Returns:	
HSIF_SUCCESS	the HSIF card closed successfully and the resources are freed.
HSIF_FAIL	the HSIF card failed to close (because the specified card was not open)

1.7.4 Sampling mode initialization

Set HSIF card to sampling mode. This must be done before the card will capture samples.

```
HSIF_RESULT HsifSamplingModeInit(
   HSIF_HANDLE hsifCard)
```

Returns:	
HSIF_SUCCESS	sampling mode entered successfully
HSIF_FAIL	unable to enter sampling mode

1.7.5 Reset PCI HSIF card

Performs a hardware reset of the PCI HSIF card. After this, all initialization must be performed again.

```
HSIF_RESULT HsifResetBoard(
   HSIF_HANDLE hsifCard)
```

Returns:	
HSIF_SUCCESS	the HSIF card was successfully reset
HSIF_FAIL	the HSIF card reset failed

1.7.6 Get Buffered Samples

This function gets up to `numSamples` samples from the HSIF card or waits until `numSamples` have been received if wait is set to TRUE. The number of samples read is returned in `numRead`.

```
HSIF_RESULT HsifGetBufferedSamples (
   HSIF_HANDLE hsifCard,
   HSIF_SAMPLE * sampleBuf,
   DWORD numSamples,
   DWORD *numRead,
   BOOL wait)
```

`sampleBuf`	Storage buffer for the retrieved samples
`numSamples`	The number of samples to read from the card
`numRead`	The actual number of samples read.
`wait`	When TRUE, the function will block until `numSamples` have been read from the card. When FALSE, the function will return immediately with 0 to `numSamples` in the `sampleBuf` as indicated by numRead

Returns:

HSIF_SUCCESS	Read up to `numSamples` successfully
HSIF_FAIL	Read failure. Possible bad HANDLE or card not esponding

Sample Contents:
`HSIF_SAMPLE` contains the following data in the specified format:

```
typedef struct {
     DWORD status;          index latches, temp, ambient,
                            amplitude, and other status info
     DWORD encoder1;        motor 1 position
     DWORD encoder2;        motor 2 position
     DWORD range;           uncalibrated range measurement
} HSIF_SAMPLE;
```

1.7.7 Set sample period and maximum range

Set the sample period and maximum range for the card. Once this data is set, it is used internally by HsifProcessSamples

```
HSIF_RESULT HsifSetSamplePeriod(
   HSIF_HANDLE hsifCard,
   HANDLE comHandle,
   DWORD range,
   DWORD samplePeriod)
```

`hsifCard`	The HSIF card's number from the above function
`comHandle`	Handle to a comport
`range`	Max measurement range, default is 650 inches.
`samplePeriod`	Period between samples in microseconds.

Returns:

HSIF_SUCCESS	Read up to `numSamples` successfully
HSIF_WARN_COM	Sample period updated internally, but an invalid com handle was specified and thus no serial communication with the AR4000 was attempted.
HSIF_FAIL	Read failure. Possible bad HANDLE or card not esponding

1.7.8 Process samples

Calculates calibrated range measurements using the samples retrieved after a call to HsifGetBufferedSamples

```
HSIF_RESULT HsifProcessSamples (
   HSIF_HANDLE hsifCard,
   HSIF_SAMPLE * sampleBuf,
   HSIF_PROC_SAMPLE * procSampleBuf,
   DWORD numSamples)
```

`HSIF_SAMPLE * sampleBuf`	samples retrieved from HsifGetBufferedSamples call
`HSIF_PROC_SAMPLE * procSampleBuf`	buffer to store results after processing samples
`DWORD numSamples`	Number of samples to process

Returns:

HSIF_SUCCESS	Processed `numSamples` successfully
HSIF_OVERFLOW	Hardware overflow bit was set in one of the samples
HSIF_FAIL	Read failure. Possible bad HANDLE or card not responding

Results Format:

`HsifProcessSamples` contains results in the following format

```
typedef struct {
     USHORT status;          FIFO and encoder index latches.
     double angle1;          motor 1 angle from offset in radians
     double angle2;          motor 2 angle from offset in radians
     double distance;        calibrated distance in inches
     double caltemp;         calibrated temperature
     double ambient;         ambient light
     double amplitude;       reflected signal strength
     BOOL timeout;           sample measurement timeout
     DWORD rawRange;         uncalibrated range
} HSIF_PROC_SAMPLE;
```

Notes:

A timeout will be set if no range reading from the AR4000 was detected after 13 ms. This can be used to detect if the range cable from the AR4000 is disconnected.

1.7.9 Load calibration file

Load calibration file for the sensor/card pair. This file is shipped with each AR4000 and PCI HSIF card set. The calibration file is used by `ProcessSamples` for generating true distance measurements.

```
BOOL HsifLoadCalibrationData (
   HSIF_HANDLE hsifCard,
   LPCSTR filename)
```

`filename` name location for calibration file

Returns:

HSIF_SUCCESS	Read successfully
HSIF_FAIL	File not found or File corrupted

1.7.10 Laser on

Enable the laser.

```
HSIF_RESULT HsifLaserOn(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Laser on output successfully set
HSIF_FAIL	Laser on output set failed.

Note:
The current AR4000 sensors do not read this output from the PCI HSIF card. To turn the laser on, use the serial command "H".

1.7.11 Laser off

Disable the laser.

```
HSIF_RESULT HsifLaserOff(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Laser on output successfully set
HSIF_FAIL	Laser on output set failed.

Note:
The current AR4000 sensors do not read this output from the PCI HSIF card. To turn the laser off, use the serial command "L".

1.7.12 Sampling enable

Enable sampling of range data from the AR4000 sensor. This function must be called after HsifClearSampleBuffer, since that function automatically disables sampling after clearing the sample buffers.

```
HSIF_RESULT HsifSamplingEnable(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Sampling enabled successfully
HSIF_FAIL	Sampling enable failed.

1.7.13 Sampling Disable

Disable sampling of range data from the AR4000 sensor.

```
HSIF_RESULT HsifSamplingDisable(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Sampling disabled successfully
HSIF_FAIL	Sampling disable failed

1.7.14 Clear overflow

Clear the hardware and software buffer overflow flags.

```
HSIF_RESULT HsifClearOverflow(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Overflow cleared successfully
HSIF_FAIL	Overflow clear failed

1.7.15 Clear sample buffer

Clear all samples that have been buffered into hardware and software.

```
HSIF_RESULT HsifClearSampleBuffer(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Samples cleared successfully.
HSIF_FAIL	Sample clear failed

1.7.16 Get number of samples available in buffer

Return the number of samples available to be read.

```
HSIF_RESULT HsifDataAvailable(
   HSIF_HANDLE hsifCard,
   DWORD * numSamplesAvailable)
```

`numSamplesAvailable`	The number of samples available is returned through this pointer.

Returns:

HSIF_SUCCESS	Accessed number of samples available successfully.
HSIF_FAIL	Could not access number of samples available.

1.7.17 Get overflow status

Return the software and hardware overflow status. If the overflow status is TRUE, the application isn't reading samples out of the buffer fast enough.

```
HSIF_RESULT HsifGetOverflowStatus(
   HSIF_HANDLE hsifCard,
   BOOL * overflowStatus)
```

`overflowStatus`	Logical and of the hardware and software overflow status.

Returns:

HSIF_SUCCESS	Returned the overflow status successfully.
HSIF_FAIL	Failed to return the overflow status.

1.7.18 Set motor power

Set power for motors 1 and 2. The powers may be set from 0 to 255, corresponding to zero power to full power.

```
HSIF_RESULT HsifSetMotorPower(
   HSIF_HANDLE hsifCard,
   DWORD motorNum,
   DWORD power)
```

`motorNum`	1 or 2 are valid motor numbers.
`power`	0 (off) to 255 (full power)

Returns:

HSIF_SUCCESS	Set the motor power successfully.
HSIF_FAIL	Failed to set the motor power.

1.7.19 Clear motor position encoder accumulator

Clear either one or both encoders immediately or the next time the index pulse comes around.

```
HSIF_RESULT HsifClearEncoder(
   HSIF_HANDLE hsifCard,
   DWORD encoderMask,
   BOOL withIndex)
```

`encoderMask`	Set to the following value to select which encoder will be cleared: `ENCODER1` – clear encoder 1 `ENCODER2` – clear encoder 2 `ENCODER1 | ENCODER2` – clear both encoders
`withIndex`	Set to the following value to select when the encoder will be cleared: TRUE – clear the encoder when the index pulse is set FALSE – clear the encoder immediately

Returns:

HSIF_SUCCESS	Set the motor power successfully.
HSIF_FAIL	Failed to set the motor power.

1.7.20 Calibrate encoder

Calibrate the encoders to return the proper angle in radians based on an offset and the number of counts per revolution. The motor angle is calculated as:

$$2 * \pi * (\text{encoderCount} - \text{offset})/\text{countsPerRev}$$

```
HSIF_RESULT HsifCalibrateEncoder(
   HSIF_HANDLE hsifCard,
   DWORD encoder,
   DWORD offset,
   DWORD countsPerRev)
```

`encoder`	Encoder 1 or 2
`offset`	Encoder count offset
`countsPerRev`	Number of counts per revolution

Returns:

HSIF_SUCCESS	Calibrated the encoders successfully
HSIF_FAIL	Failed to calibrate the encoders.

1.7.21 Calibrate HSIF card

The PCI HSIF card must be calibrated to ensure accurate range readings in a given enviornment. This must be performed at least once after calling HsifOpen. Calibrations should be performed periodically if the environmental conditions the card is exposed to will vary. The procedure takes several seconds to perform.

```
HSIF_RESULT HsifCalibrate(
   HSIF_HANDLE hsifCard)
```

Returns:

HSIF_SUCCESS	Card was calibrated successfully
HSIF_FAIL	Failed to calibrate the card

1.7.22 Set poll mode

Enable polling mode when the sample period is large. If this is set to FALSE, there will be a latency of 2048 samples between transfers from the HSIF card buffer to PC's local memory.

```
HSIF_RESULT HsifSetPollMode(
   HSIF_HANDLE hsifCard,
   BOOL mode)
```

Returns:

HSIF_SUCCESS	Poll mode was successfully set.
HSIF_FAIL	Failed setting poll mode

1.8 Serial I/O Utilities

The Serial I/O Utilities comprise a set of functions for accessing the AR-4000 sensor through the serial port. These functions are used internally by the HSIF Library for setting the resolution and range of the AR-4000 sensor if the address of an open COMMINFO struct is passed to the HsifOpen routine when opening access to the card, or during a call to HsifSetSamplePeriod.

1.8.1 Open a com port to communicate with an AR-4000 sensor

Open a com port at the baud rate specified.

```
BOOL OpenPort(
   COMMINFO *pCommInfo,
   int baudrate,
   int Portnum)
```

`pCommInfo`	pointer to a COMMINFO struct where relevant com port information is stored
`baudrate`	baud rate the sensor is configured for. Normally this is 9600.
`Portnum`	com port number to open

Returns:

TRUE	Com port was successfully opened
FALSE	Com port open failed.

1.8.2 Close com port

Close com port.

```
BOOL ClosePort(
   COMMINFO *pCommInfo)
```

pCommInfo	pointer to a COMMINFO struct where relevant com port information is stored.

Returns:

TRUE	Com port close was successful
FALSE	Com port close failed

1.8.3 Purge port

Clear out pending transmit and receive data

```
BOOL PurgePort(
   COMMINFO *pCommInfo,
   int flags)
```

pCommInfo	pointer to a COMMINFO struct where relevant com port information is stored.
flags	Possible settings: PURGE_TX - clear transmit buffer PURGE_RX - clear receive buffer These values can be "bitwise OR'd" for simultaneous operation, i.e. PURGE_TX | PURGE_RX

Returns:

TRUE	Purge was successful
FALSE	Purge failed

1.8.4 Send serial data to the AR-4000 sensor

Send a string of characters to the AR-4000 sensor.

```
BOOL sendstr(
   COMMINFO *pCommInfo,
   char str[])
```

pCommInfo	pointer to a COMMINFO struct where relevant com port information is stored.
str	null-terminated string of characters to transmit to the AR-4000 sensor

Returns:

TRUE	String was transmitted successfully
FALSE	String transmit failed.

1.8.5 Read a line of characters from the AR-4000 sensor

Read a line of characters from the AR-4000 sensor when in ASCII output mode.

```
unsigned int ascii_read_line(
   COMMINFO *pCommInfo,
   char *buf,
   unsigned int nMaxLength,
   BOOL crlf,
   int timeout)
```

pCommInfo	pointer to a COMMINFO struct where relevant com port information is stored.
buf	storage space for characters read from the AR-4000 sensor
nMaxLength	maximum number of characters that can be put in the *buf* storage space
crlf	TRUE - read a carriage return/line-feed pair as the end of line indicator. FALSE – read a line-feed as the end of line indicator. This should be set to TRUE for AR-4000 sensor.
timeout	Number of milliseconds to wait before returning from the call if no data is detected.

Returns:

number of bytes read	If read was successful.
ASCII_TIMEOUT	If read times out.

1.8.6 Read binary data bytes from the AR-4000 sensor

Read a specified number of bytes from the AR-4000 sensor when in binary mode.

```
unsigned int ascii_read_line(
   COMMINFO *pCommInfo,
   char *buf,
   unsigned int nMaxLength,
   int timeout)
```

`pCommInfo`	pointer to a COMMINFO struct where relevant com port information is stored.
`buf`	storage space for characters read from the AR-4000 sensor
`nMaxLength`	maximum number of characters that can be put in the *buf* storage space
`timeout`	Number of milliseconds to wait before returning from the call if no data is detected.

Returns:

number of bytes read	If read was successful.
BINARY_TIMEOUT	If read times out.

1.9 Sampled Data Format

The interface board collects 16 bytes/sample in a sequential stream which are read as samples with function `HsifGetBufferedSamples`. If memory buffer overflow occurs, the board will always drop complete samples, so that synchronization is not lost. If a software board reset command is issued, the next byte read will be the first byte of a complete sample, and unread and partially read samples will be lost.

In general the values for amplitude and ambient light level, will correspond closely to the values from the 4000's serial interface, with the ASCII format serial data being 4 times the High Speed Interface values for amplitude and ambient light. However, the values will not match exactly, and the calibration software supplied for use with the High Speed Interface must be used with the values obtained from the HSIF, not serial data. The temperature and range have different scale factors from the serial data and must be scaled using algorithms found in the software supplied with the interface. Below is a table that details the sample data format:

DWord #	Bit #	Contents
0	0	Hardware Buffer Overflow Indicator
	1	Input 3
	2	Motor 1 Encoder Index / Input 1
	3	Motor 2 Encoder Index / Input 2
	7-4	Sample Count 0-15
	15-8	8-bit Sensor Internal Temperature
	23-16	8-bit Ambient Light Sample
	31-24	8-bit Amplitude Sample
1	31-0	32-bit Motor 1 Encoder Position
2	31-0	32-bit Motor 2 Encoder Position
3	31-0	32-bit Range
Sampled Data Format		

1.9.1 Description of Sampled Data Format

Amplitude: 8-bit sample of the AR4000 logarithmic signal strength output. The sample represents the amplitude of the modulated signal sensed by the detector. The amplitude sample is taken in the first 10 microseconds of the data sample interval.

Ambient Light: 8-bit sample of the AR4000 ambient light output. The sample represents the ambient or background light sensed by the detector. It will also register the light transmitted by the sensor, so changing range signal strengths will affect this reading somewhat. The ambient light sample is taken in the first 10 microseconds of the data sample interval.

Internal temperature: 8-bit sample of the AR4000 internal temperature. The temperature is sampled in the first 10 microseconds of the data sample interval.

Range: 32-bit value which must be processed through HsifProcessSamples to get a rawRange value that will be proportional to the distance to the object being ranged, within the uncalibrated linearity of the AR4000.

Buffer overflow indicator: 1 bit indicating whether a memory buffer overflow occurred and 1 or more samples were lost just prior to the first sample in which the flag is set. Once an overflow occurs, this bit will stay set until a HsifClearOverflow or Reset Interface Board command is given or a power cycle occurs. Samples with the overflow flag set may contain inaccurate range data and should be discarded. Since the overflow flag is stored with the buffered data, resetting the flag will not become evident in the data until the data in the buffer has been read, or the buffer has been cleared with a board reset command. Note that if the buffer is full when the HsifClearOverflow command is given, it will simply be set again immediately.

Inputs 1, 2, 3: 3 general purpose input lines, CMOS logic levels. These may be used to determine the exact times of external events relative to the samples taken.

Inputs 1 and 2 are set on the positive rising edge of signals input to these pins. After the next sample is written, the inputs are automatically cleared. Input 3 is a general purpose, level-sensed input.

Motor 1, 2 Encoder Index: Indicates when a motor has completed a revolution. When Inputs 1 and 2 are used to indicate motor encoder index they will be unavailable for use as general purpose inputs.

Motor 1 Encoder Position: 32-bit sample of the position of motor encoder 1, if the motor control option is installed and a motor encoder is attached to the P2 motor 1 encoder inputs. The position will wrap to 0 after reaching ~ 4.3 billion.

Motor 2 Encoder Position: 32-bit sample of the position of motor encoder 2, if the motor control option is installed and a motor encoder is attached to the P2 motor 2 encoder inputs. The position will wrap to 0 after reaching ~ 4.3 billion.

1.10 Interface Installation and Checkout

To install the AR4000 PCI High Speed Interface board, first install the computer drivers from the supplied CD according to the directions in section 1.2. When complete, physically install the PCI board into an available PCI slot in your computer. Attach the AR4000 Power and Signal cable to the 9 pin connector (P1). Turn on the computer power. Check out the operation of the AR4000 as described in the Initial Checkout section.

1.10.1 Diagnostics

Install the PCI High Speed Interface in a bus slot, connect the sensor to the HSIF board and to a serial port on the computer. Be sure that power is being supplied to the AR4000 sensor.

If the sensor's LED does not come on, check the connection of the sensor to the interface. The serial connection to the sensor may be tested separately using a program such as the Windows terminal to observe sensor output and send commands. If the sensor does not respond to serial communications, check the serial port connection.

After installing the board and connecting the AR4000 sensor, run the demo/diagnostic software supplied with the board, following the instructions at the beginning of this manual.

If the motor control option is not installed, the encoder tests will not succeed. If you have not connected the input lines and external sample control line to 0/5 volt signals, the tests of those lines will not succeed. All other tests should succeed.

If the one or more of the Interface tests fail, check the port address you give the diagnostic software. Also make sure that no other boards in the computer system are using the address group. Verify that the serial port the sensor is connected to is the port number you give the diagnostic software. Check that the sensor's serial port is configured for 9600 baud.

If the sensor stability tests fail, check that the laser comes on during those tests and that the sensor is pointed a white target 1 to 2 yards from the sensor.